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Power System Stability Using Feedback Control System Modelling for HVDC Network

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ABSTRACT: HVDC systems offer better controllability and improvement of global power-system stability, there is also an increased risk for local instabilities which can either start as parasitic small signal oscillations, or concurrent commutation failure of converters consequently impair voltage quality or cause high over-voltage at the converter ac buses. This paper propose a implementation based on a small-signal stability, voltage stability, and interaction phenomena of power systems with both line-commutated-converter HVDC (LCC-HVDC) and voltage-source-converter HVDC(VSC-HVDC) are addressed using the proposed implementation. This proposed work is implemented in MATLAB/SIMULINK environment.

KEYWORDS: MATLAB, Simulink, LCC, HVDC, Transmission links, power system, Stability.

I. INTRODUCTION

The increasing number of high-voltage dc (HVDC) transmission links, imposes the serious challenges on power system control and stability analysis. While some of HVDC systems offer better controllability and improvement of global power-system stability, there is also an increased risk for local instabilities which can either start as parasitic small signal oscillations, or concurrent commutation failure of converters consequently impair voltage quality or cause high over-voltage at the converter ac buses. To analyze the nature and causes of these instabilities, appropriate analytical models of power systems and HVDC links are required. The electro-magnetic transient programs (EMTPs), as time-domain simulation tools, demonstrate instabilities; however, they do not provide the analytical insight (e.g., information about participants in instability or stability margins) needed for optimal system design. In addition, these programs have practical simulation restrictions on the extent of the ac system. The conventional transient stability programs (TSPs), which use phasor modeling techniques, do not have these aforementioned problems, but they cannot directly represent the faster transients characterizing the HVDC systems. These models are usually used in local studies, where a small portion of power system including HVDC converter is modeled in detail and the rest of the power system is replaced by an equivalent simple circuit.

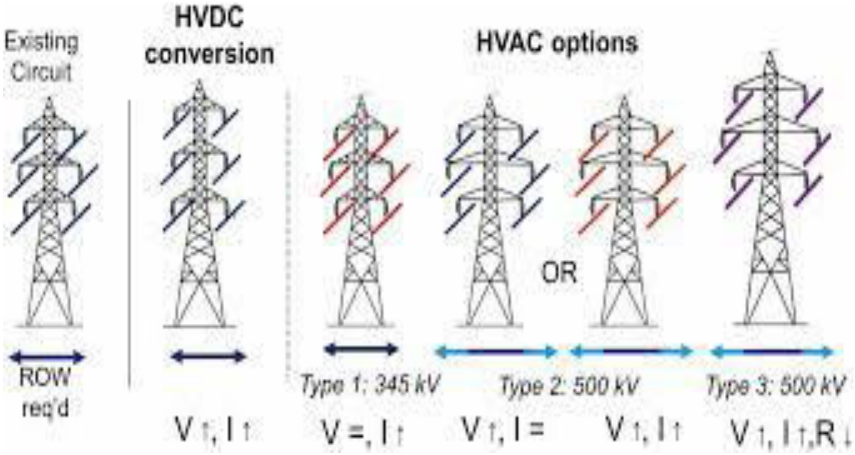


Figure 1: HVDC

However, when the number of HVDC converters (and/or other power-electronic devices) is increased, the high-frequency interaction between different devices will be so complicated that local analysis may not result in a reliable conclusion. Moreover, that the HVDC controller design might suffer from lack of an accurate power system model if only the dynamics of a small portion of it is regarded. On the one hand, considering dynamics of all power components and ac system results in a huge number of state variables, of which most of are in essential. On the other hand, all of the electrical network dynamics cannot be neglected while analyzing the interactions among HVDC converters (otherwise, the TSPs could have been used for the same purpose).

II. PROPOSED MODEL

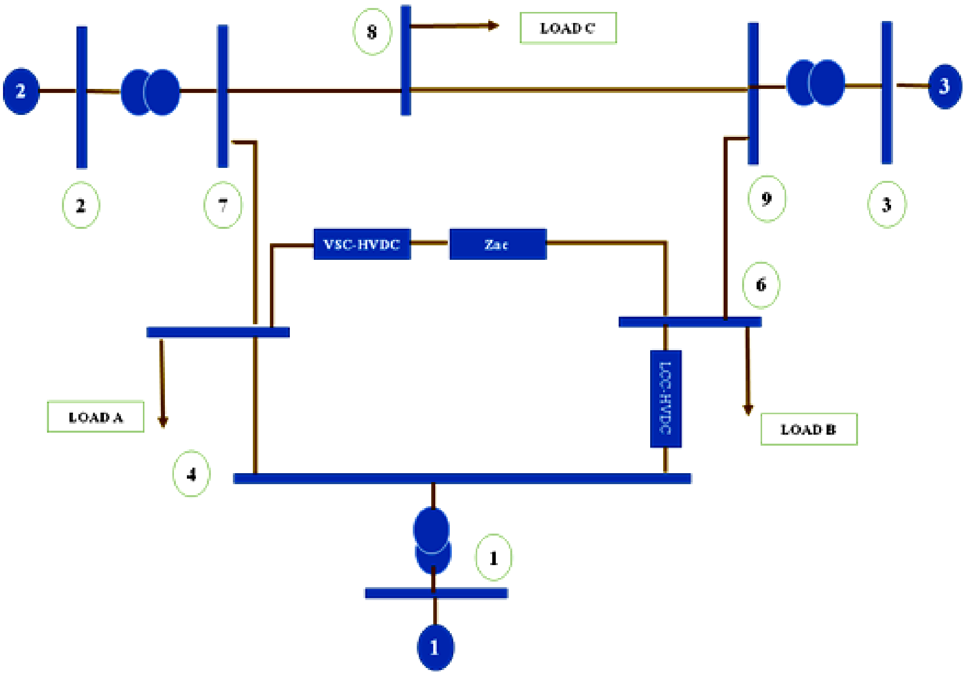


Figure 2: Flow Chart

High-voltage DC transmission based on voltage source converters (VSC-HVDC) presents a solution for many problems face nowadays by power networks, such as, network congestions, grid re-enforcements, wind farms connection, multi-terminal operation and asynchronous connections. Currently, there are two established approaches for the construction of a VSC-HVDC system. The first approach uses a standard two-level converter or a neutral-point clamped converter with forced commutated devices such IGBTs. This approach imposes a high insulation requirement on the interfacing transformer due to the high dv/dt that results from switching high voltage with relatively low switching frequencies. This arrangement also requires fairly large filters at the output to attenuate the switching frequency components from the output voltage at the point of common coupling. The second approach uses a two-switch modular multilevel converter with medium voltage devices such as 4.5 kV IGBTs. This approach produces lower dv/dt (allowing the use of a transformer with standard insulation requirements) and significantly lower voltage harmonic distortion (which may eliminate the need for the AC filters).

To develop the FCS model for entire power system, it is necessary to model the ac network as a hybrid model as developed. The hybrid model of the ac network means that the model is separated into two parts, namely, the dynamic and static parts. The dynamic part or dynamic area is where the HVDC converters and their surrounding ac components, such as the ac lines and transformers, are modeled dynamically using the space vector theory. The static part is the remaining part of the ac network where there are no HVDC converters. In this area, the ac components are modeled as constant admittances using the phasor theory. The electric parts of the input devices inside block I have two input vectors and one output vector. One of the input vectors originates from the control systems in K and the other one, which is the power vector, originates from the ac network in N. The output vector yin fed to the ac network in N contains the amplitudes and angles of the input device alternating voltages. The VSC-HVDC outputs are the rectifier alternating voltage amplitude, rectifier direct voltage, rectifier alternating current vector, inverter alternating voltage amplitude, inverter active power, and the inverter alternating current vector, respectively. It must be analyzed that the VSCs alternating current vectors and are used in high-pass filters in the block for oscillations damping purposes.

III. SIMULATION RESULTS

The implementation of the proposed algorithm is done over MATLAB software. The signal processing toolbox helps us to use the functions available in MATLAB Library for various methods like Windows, shifting, scaling etc

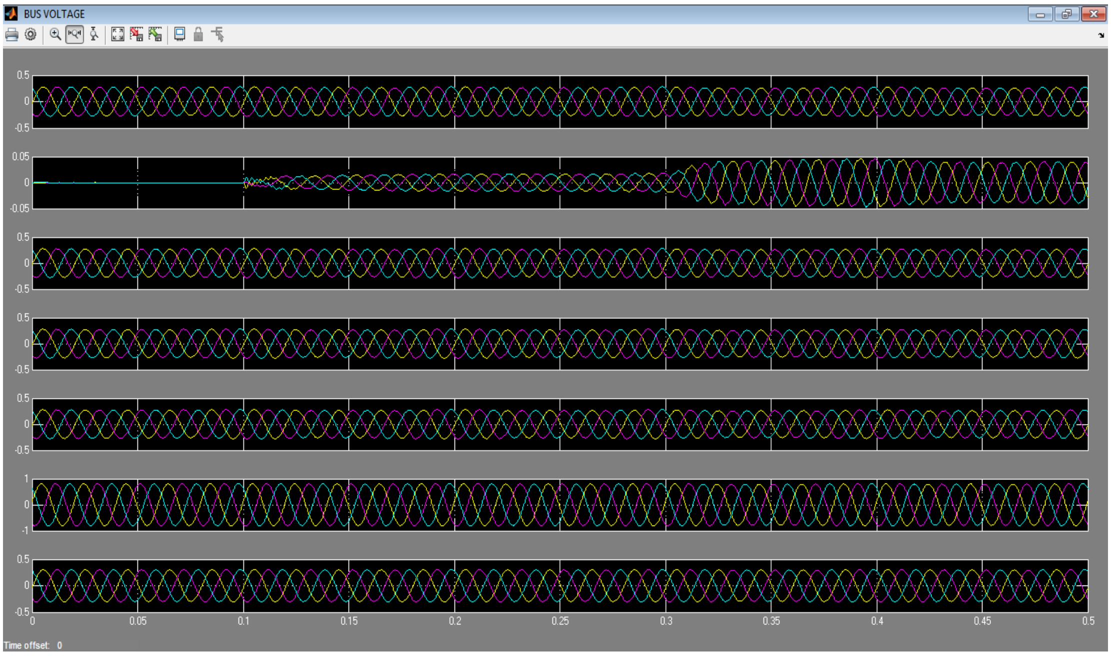


Figure 3: Bus voltage waveform

Bus voltage is the voltage on a Bus bar. Bus bars are rigid copper bars (mostly) into which all the generated current (generated from multiple alternators in AC system or from rectifiers in DC system) is fed and through which it is then distributed or further processed.

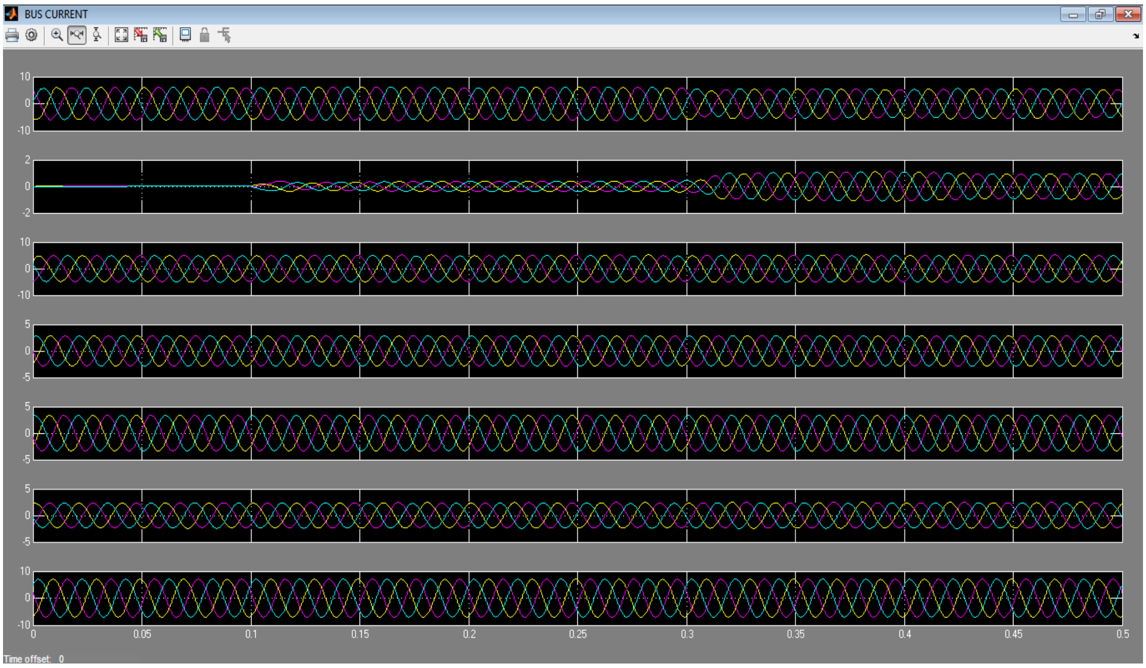
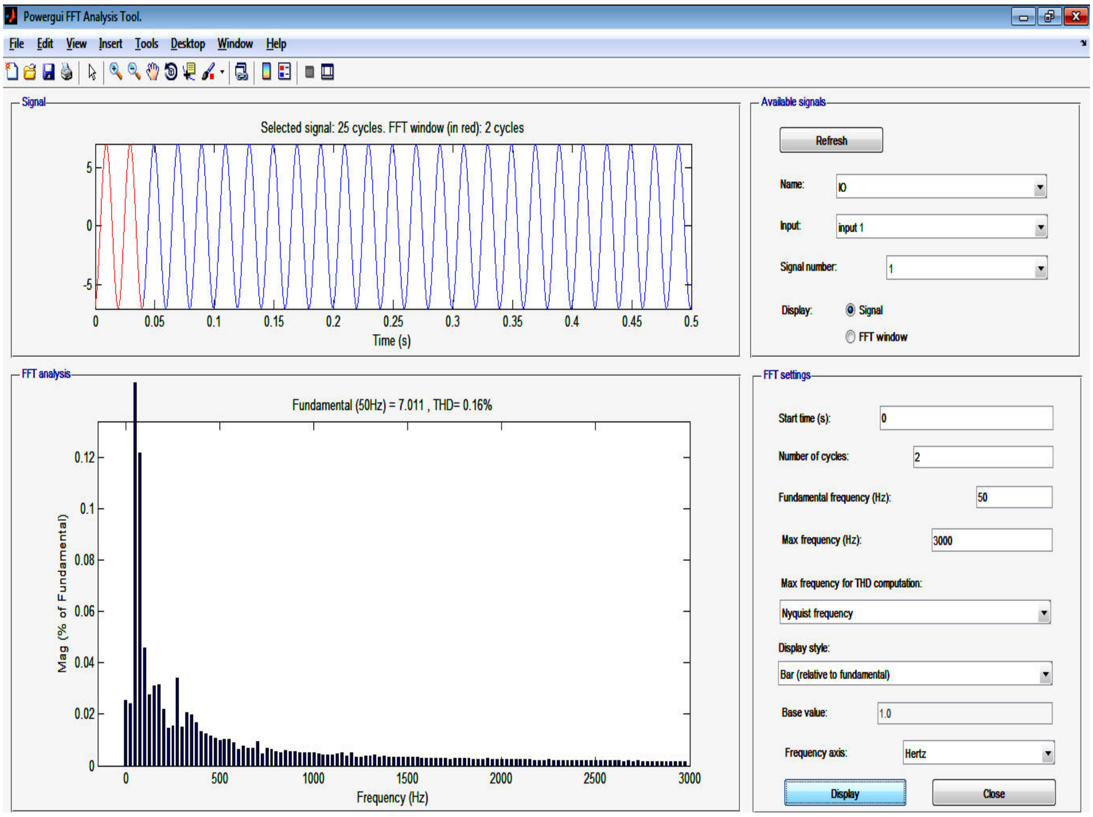


Figure 4: Bus current waveform

Bus" is any graph node of the single-line diagram at which voltage, current, power flow, or other quantities are to be evaluated. This may correspond to the physical busbars in substation.



Name: I0

Input: input 1

Signal number: 1

Display: ● Signal ○ FFT window

Start time (s): 0

Number of cycles: 2

Fundamental frequency (Hz): 50

Max frequency (Hz): 3000

Max frequency for THD computation: Nyquist frequency

Display style: Bar (relative to fundamental)

Base value: 1.0

Frequency axis: Hertz

Figure 5: THD for bus 9 current waveform

The total harmonic distortion use for the measurement of the harmonic distortion present in a signal and is defined as the ratio of the sum of the powers of all harmonic components to the power of the fundamental frequency.

Table 1: Simulation Parameters

Sr No	Parameters	Value
1	Signal Cycle	25
2	FFT window cycle	2
3	Amplitude	5
4	Total harmonic distortion	0.16%
5	Frequency	3000Hz

Table 2: Results Comparison

Sr No	Parameters	Previous Results	Proposed Results
1	Real power	1 pu	1.5 pu
2	Reactive power	-0.8 pu	-1 pu
3	THD	0.57%	0.16%

Therefore the proposed model provides the sending and receiving end frequencies are independent. Transmission distance using DC is not affected by cable charging current. The installation is isolated from mainland disturbances, and vice versa. Power flow is fully defined and controllable. Low cable power losses obtain. Higher power transmission capability per cable.

IV. CONCLUSION

This paper proposed of power system stability using feedback control system modelling including HVDC transmission links model. It will not be necessary to change the circuit breakers in the existing network. HVDC can carry more power for a given size of conductor. It is also use for implementing stability interactions among multiple power-electronics devices in the power system from a feedback control theoretic perspective. To make FCS model be applicable for large power system, a hybrid model of ac network was adopted.

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